

Guest Editorial

THE IEEE International Workshop on Plasma Cosmology was held in La Jolla, California, on February 20-22, 1989, bringing together for the first time observers and plasma physicists working on topics of astrophysical and cosmological importance [1]-[3] (Fig. 1). E. J. Lerner (Lawrenceville, NJ), F. Yusef-Zadeh (Northwestern University), A. L. Peratt (Los Alamos National Laboratory) and W. Peter (Los Alamos National Laboratory) served as Workshop organizers.

The papers in this Special Issue are among those presented at the Workshop and are organized in the order of the workshop sessions: (i) The Plasma Universe, (ii) Plasma Processes in Galaxy Formation, (iii) Galaxies: High-Z Observations and Mass Determination, (iv) Large-Scale Structure in the Distribution of Galaxies, (v) Cosmic Background Radiation, and (vi) Nonrecessional Explanation of the Hubble Relation.

In this issue, H. Alfvén (University of California, San Diego) gives an introductory exposition of cosmology in the plasma universe. The acceptance of the plasma universe model has led to a reinterpretation of the structure of the universe. Space is filled with a network of currents which transfer energy and momentum over large or very large distances. Electric fields, especially in the context of double layers [4], are expected to be responsible for many of the energetic events and electromagnetic radiation observed in the cosmos. C.-G. Fälthammar (Royal Institute of Technology, Stockholm) points out that in cosmology, as in astrophysics, the overwhelmingly dominant state of matter is the plasma state. Therefore, it is necessary to take into account the properties of plasma in the development of cosmology. Fälthammar underlines the difficulty of this task in light of the fact that matter in the plasma state is characterized by a complexity which vastly exceeds that exhibited in the solid, liquid, and gaseous states. Correspondingly, the physical, and especially the electrodynamic properties of the plasma are still far from well understood. T. E. Eastman (University of Maryland) reports on the transition regions that abound in astrophysical plasma, even though most are not visible. In the solar system, *in situ* measurement of transition regions has revealed their importance in a number of dynamic physical processes such as kinetic and macroscopic instabilities, magnetic dynamos, coherent emission of radiation, and long-range coupling via field-aligned currents [5].

A. L. Peratt presents evidence for the existence of electrical currents in the plasma universe by comparing the synchrotron radiation intensities and isophotes of quasars and double radio galaxies to simulation and laboratory models of z pinches. The fully three-dimensional, electromagnetic, particle-in-cell simulations suggest that ap-

parently unrelated radio galaxies or quasars are all part of the same species, but are only at different stages of development on their evolution towards becoming spiral galaxies. Studies of the latter show 1-mG toroidal-poloidal magnetic fields in simulated spiral galaxies. High-resolution radio continuum observations made at centimeter and decimeter wavelengths of the center of our Galaxy by F. Yusef-Zadeh, M. Morris, and D. Chance [6] (Fig. 2) revealed numerous filamentary structures in the inner 100 pc (3×10^{18} m or 317 light years) of the Galaxy, ~ 0.3 pc in diameter by 10-50 pc in length. The filaments are highly polarized, indicating a synchrotron origin for their radio emission. The filaments are roughly perpendicular to the galactic plane suggesting that the observed 1 mG magnetic field is poloidal in a cylindrically symmetric force-free configuration. R. Beck (Max-Planck-Institut für Radioastronomie, Bonn, FRG) reports on the measurement of magnetic fields in spiral galaxies with the 100-m Effelsberg radio telescope. Two different field patterns are observed: Axisymmetric-spiral and bisymmetric-spiral. The field patterns away from the plane, as measured from edge-on galaxies, are neither dipole nor quadrupole, but seem to be influenced by the plasma outflow (a "galactic wind"). Long magnetized filaments are seen, up to 30 kpc (10^{21} m) in length.

M. J. Valtonen (University of Turku, Finland) describes the computer simulations that he and G. G. Byrd (University of Alabama) have used to determine the masses of galaxies, groups of galaxies, and clusters of galaxies. Red-shift asymmetries are used to separate binary pairs from optical pairs in catalogs of galaxy pairs. It is found that the so-called cluster missing mass cannot exist for dynamical reasons, and the high velocity dispersion of member galaxies is more likely to indicate incomplete virialization than a high mass.

R. B. Tully and J. R. Fisher [7] report that it is becoming increasingly evident that galaxies tend to lie within an interconnected network of filaments and that elsewhere there are vast regions devoid of visible matter. A summary of the current observational situation (Fig. 3) indicates clustering on a scale of one-tenth the Hubble radius. The popular cold, dark matter gravitational model fails to anticipate the apparent very large clustering. Corroboration of the large-scale structure comes from P. A. Shaver's use of radio galaxies and quasars as probes of large-scale structure [8]. Shaver reports a very large-scale structure out to dimensions of nearly one-half the Hubble radius; a distribution of quasars in a structure of width $\sim 400 h^{-1}$ Mpc at a corresponding distance of $\sim 800 h^{-1}$ Mpc ($2.6-5.2 \times 10^9$ light years).

The cosmic microwave background, as measured by the submillimeter Nagoya-Berkeley rocket measurements [9],

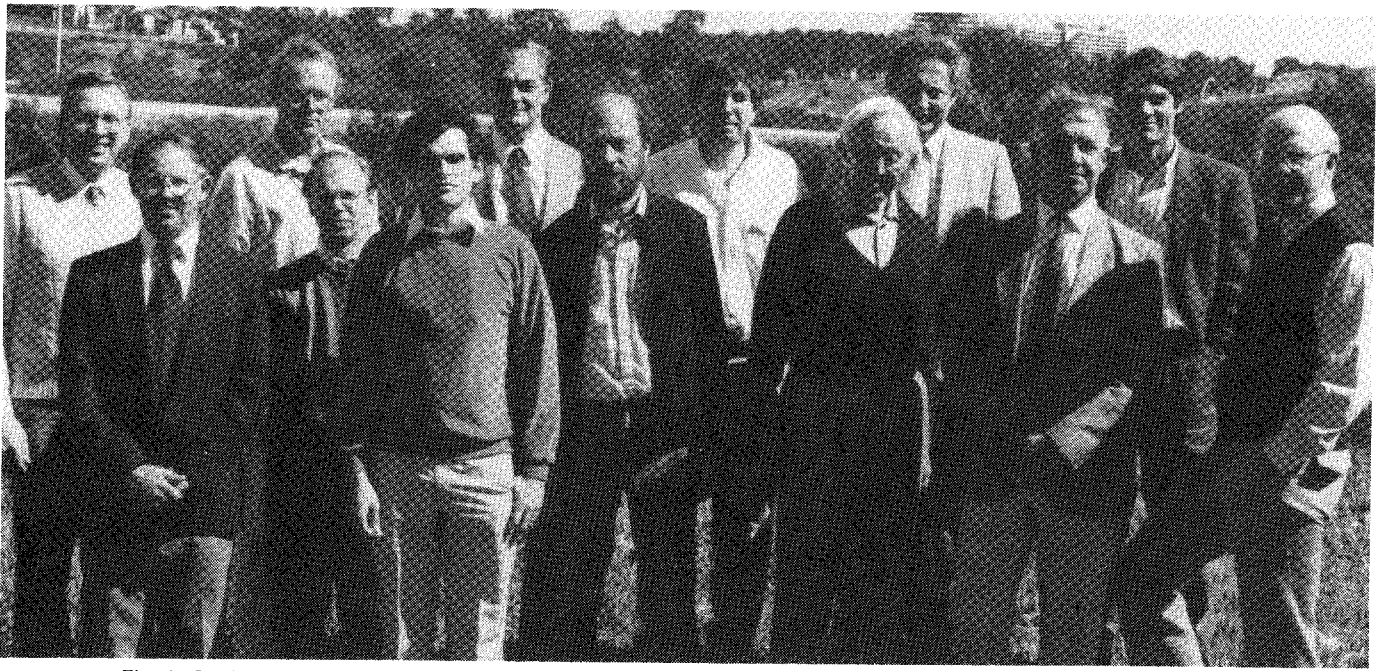


Fig. 1. Participants in the IEEE International Workshop on Plasma Cosmology. From left: T. E. Eastman (University of Maryland), A. L. Peratt (Los Alamos National Laboratory), R. B. Tully (University of Hawaii), M. J. Valtonen (University of Turku, Finland), E. J. Lerner (Lawrenceville, NJ), P. Marmet (Herzberg Institute of Astrophysics, Ottawa, Canada), R. Beck (Max-Planck-Institut für Radioastronomie, Bonn, FRG), W. Peter (Los Alamos National Laboratory), H. O. G. Alfvén (University of California, San Diego), M. Finkenthal (Johns Hopkins University), C.-G. Fälthammar (Royal Institute of Technology, Stockholm), M. Morris (University of California, Los Angeles), and P. A. Shaver (European Southern Observatory).

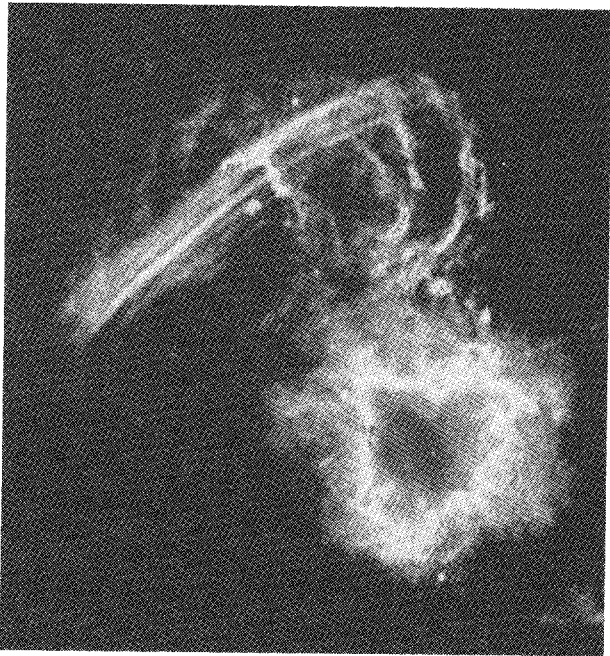


Fig. 2. Very Large Array (VLA) radiograph of large-scale 20-cm radio emission features from the magnetized filamentary plasma structure within approximately 60 pc (1.8×10^{18} m) of the Galactic nucleus. The galactic plane runs from top-left to bottom-right through the lower diffuse structure. Velocities of matter in this region indicate that magnetic fields, and not a "black hole," are responsible for plasma structure. (Photograph courtesy of F. Yusef-Zadeh.)

is discussed by E. Lerner. Lerner also reports on a plasma model of galaxy formation which shows that helium, deuterium, lithium, beryllium, and boron, as well as heavy

elements such as carbon and oxygen, can all be produced in correct amounts by an early generation of intermediate mass stars. These stars also generate an amount of energy comparable to that of the cosmic background radiation. The model predictions agree very well with recent observations. W. Peter gives an analysis of the radiation spectrum of synchrotron-emitting electrons in galactic-sized Birkeland current filaments. Simulations of the interacting filaments produce 1.2×10^{-13} erg/cm³ during a burst of synchrotron radiation. This energy density is close to the 4.5×10^{-13} erg/cm³ of the cosmic microwave background. If the cosmic microwave background spectrum is due to absorption and re-emission of radiation from these current filaments, higher-order synchrotron modes are not as highly self-absorbed as lower-order modes, resulting in a distortion of the blackbody curve at higher frequencies. These distortions may be measurable by the Cosmic Background Explorer satellite (COBE), whose detectors cover the range of 1 cm to 1 μ m, that is expected to begin taking measurements in early 1990.

This Special Issue concludes with a discussion of non-Doppler red-shift mechanisms. P. Marmet (Institute Herzberg d'Astrophysique, Ottawa, Canada) presents the case for Hubble's red-shift interpreted by means of the emission of bremsstrahlung. J. Kierein (Ball Space Systems) discusses the implications of the Compton Effect interpretation of the red shift. This effect, as suggested by Compton, provides a possible mechanism for intrinsic red shifts of quasars and the solar limb and results in a new cosmological model. J.-P. Vigier (Institute Henri Poin-

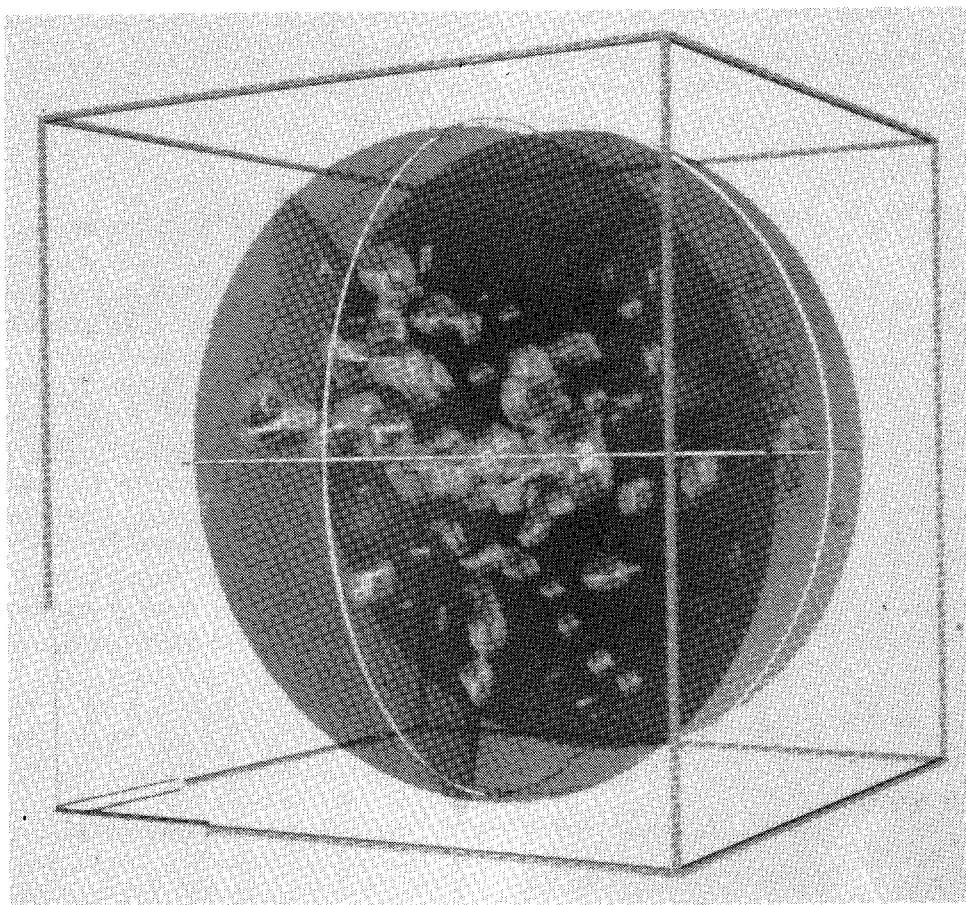


Fig. 3. The largest object discovered so far in the universe is a cluster of superclusters of galaxies. The distribution of 382 rich clusters in filaments is shown. The radius of the sphere is 600 Mpc (2×10^9 light years). This discovery was in agreement with the plasma universe model which predicts that galaxies form in filaments in sheets of current-conducting plasmas at very large scales. (Photograph courtesy of R. B. Tully.)

caré, Paris) reports on recent laboratory observations that suggest a frequency anisotropy in the direction of the constellation Leo. This is interpreted as evidence for nonzero mass photons leading to a vacuum-induced dissipative redshift mechanism. H. Arp presents a commentary on tired light mechanisms. A. L. Peratt suggests that the Wolf Effect may be responsible for quasar red-shifts. Correlations between fluctuations of the source distribution at two different source points can produce red shifts or blue shifts to any magnitude that are indistinguishable from the Doppler shift. This effect may play an important role in the plasma universe, since coupling between sources generally produces a forward-directed radiation pattern where only a redshift can be observed [10].

With the application of plasma science to cosmology, many of the increasing number of "mysterious" or "puzzling" discoveries in astrophysics appear to be predictable or explainable without appealing to the existence of exotic objects of unknown or questionable origin. It is hoped that the papers in this Special Issue have helped establish a framework within which the problems associated with plasma and the universe can be identified.

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